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ART. XII.—*On the Cause of the external Pattern, or Watering of the Damascus Sword-Blades, by* HENRY WILKINSON, Esq.

Read April 1st, 1837.

IT is well known that Damascus was formerly celebrated all over the world for its manufacture of sword-blades, and it is recorded, that when Timúr Lang conquered Syria, in the beginning of the fourteenth century, he carried off all the manufacturers of steel into Persia; since which period, the fabrication of arms has declined at Damascus, and the successors of those workmen, being dispersed over the East, are said either to have lost the secret, or ceased to make blades of more than ordinary goodness. We must, however, first divest ourselves of all prejudice in favour of the exaggerated reports of their qualities, and remember, that at the time when the natives of the East were well acquainted with the art of working in iron and steel, we, and indeed all Europe, appear to have been comparatively in a state of perfect ignorance; the ancient swords of Damascus, therefore, when opposed to those of other countries, were probably found to be infinitely superior in temper and quality; which, combined with their great external beauty, stamped them for ages with so high a character for excellence, that they are even now handed down as heir-looms by Eastern princes to their posterity. The extraordinary prices[1] that have been offered and obtained for them, sufficiently attest the estimation in which they were held, which is certainly not warranted in the present day, when swords of equal, or superior quality, might be manufactured at one-twentieth of the expense. In addition to the foregoing observations, the strength and great dexterity of the swordsmen must be taken into consideration, and much of the apparent superiority of these blades may be undoubtedly ascribed to this cause.

The attempt to imitate them has, however, occupied the attention of philosophers and manufacturers in various countries, and at different periods; but these attempts have been mostly directed to produce the external appearance, rather than to attain any superior quality, for which the original swords were famed, and the explanation of the true cause of the watering, or *Jowher*, (which, in my opinion, has never been successfully imitated,) is still a desideratum. With this view I have attentively pursued the subject for several years, and finally came to the conclusion that the natives of the East are either perfectly ignorant of the cause themselves, or, finding their labours so highly appreciated, have mystified the process as much as possible, in order to avoid the discovery of having no secret to keep.

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[1] Two swords presented to Sir John Campbell by the Shah of Persia, were valued at 200 ducats each, or about 80*l*. And the Umeer of Scind had a large sword, for which he refused 9000 rupees, equal to 900*l*.

With respect to the various attempts at imitation, the least ingenious one is certainly that of etching, or engraving, a blade of common steel, merely to deceive the purchaser. Amongst the numerous failures, we may enumerate those of Messrs. Nicholson, O'Reilly, Wilde, and others in England, as well as that of Monsieur Clouet, in France, whose treatise entitled, "*Art de fabriquer les Lames figurées, dites Lames de Damas*," does not contain any method capable either of imitating the figure, or the boasted qualities of the real blades; which is clearly demonstrated by Signor Crivelli, in a memorial published at Milan, in 1821, "*Sull' Arte di fabricare le Sciabole di Damasco*," in which the author considers that he has discovered the great secret; but, although his method is extremely ingenious, and, in my opinion, calculated to produce swords of great beauty, and equal to any ever made at Damascus, yet I think I may be able to prove that his conclusions are erroneous, and that he has mistaken a natural appearance for an artificial one. Another method, adopted in ignorance of the true cause, or merely for the sake of ornament, is not uncommonly met with in Georgian swords and daggers, and in those of Russia, and other countries, forming a central line along the blade, and made by a process similar to that employed for the manufacture of gun-barrels in India, and now well known in Europe; consisting of alternate laminæ of iron and steel, twisted in a spiral direction, and welded together; this arrangement is, however, totally different to the true Damascus, and wholly unfit for the edge of any cutting instrument, being incapable of producing uniformity of temper. A few celebrated swords made by Goork of Taflis, almost all of which are at present in the possession of Kings, are made of Georgian steel, the ore being obtained from the Siberian mines; they have a broad band of this kind of artificial Damascus near the back of the blade. One of them I have lately examined, and do not consider it superior to those of our own general make, in respect to its useful qualities; the band being merely an ornamental introduction.

The conviction in my own mind that secrets of importance in manufactures can rarely be kept for centuries, induced me to seek for the cause in the material employed; and I think that in China, and other places, where the natives excel in the production of any particular article of commerce, we must generally attribute it to the quality of the material, and the method of manipulation, rather than to the superior skill and knowledge of the workmen. Unavoidable results are often obtained, depending on circumstances unknown to themselves, and, therefore, easily preserved from the curiosity of others.

The *Jowher*, or watering, of the genuine Damascus sabres, I conceive to have been originally produced by two principal causes; first, the nature of the iron-ore; secondly, the method of converting it into steel. The latter differs in various provinces of India, but is essentially the same, as I find by the MSS. of Dr. Moorcroft, and Major James Franklin, and also by other documents.[1] The furnace is of a rude description, being composed of stones and mud, or clay; the iron-ore is reduced to a coarse powder; the furnace being filled with charcoal,[2] the fire is urged by bellows until no moisture is given out; a small basketful of the ore is then poured in at the top, and a larger basketful of charcoal, and so on alternately. The scoria begins to run in about an hour; the bellows are incessantly worked by men relieving each other, and in about twelve hours the process is finished. The crude iron thus obtained has never been really melted, but falls by its weight to the bottom of the furnace, where the grains agglutinate: in this state it is often malleable. The wall of the furnace is broken down—the red-hot mass dragged out, and divided into pieces of one or two pounds' weight. To convert it into steel, each piece is put into a crucible, with a handful of dried branches,[3] and the mouth is closed up with mud: the crucibles are arranged in a circle, in a hole dug in the ground, the cavity is filled with charcoal, and a strong heat is kept up for six hours: the crucibles are then sprinkled with water to cool them, and the steel is found at the bottom; but some of the crucibles contain part iron and part steel, and others have cracked and allowed the metal to flow out. The cakes of steel are called *wootz:* they differ materially in quality, according to the nature of the ore, but are generally very good steel,[1] and are sent into Persia and Turkey, where such as are suitable for the purpose are manufactured into sword-blades, razors, and other articles of cutlery.

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[1] In Vol. i., p. 245, of the "Journal of the Asiatic Society of Bengal," there are some interesting particulars relative to the native manufacture of steel in Southern India, extracted from the MS. Journals of the late Dr. Voysey; and at page 253 of the same Journal, some observations are made on the Salem Ironworks. Dr. Heyne has published his "*Tracts on India*," in which he fully describes the method of manufacturing iron and steel in various parts of India. The MSS. of Dr. Moorcroft and Major James Franklin are in the library at the East India House.

[2] Bamboo-charcoal is said to be preferred, probably in consequence of the quantity of silica it contains, which acts as a flux.

[3] The dried branches of the Cassia auriculata, and the fresh leaves of the Convolvulus laurifolia, are employed.—Dr. Heyne.

This is the kind of steel that has always been employed for those blades so celebrated for their beauty, and I consider that it would be as impossible to forge a sword-blade out of some of these materials, when properly selected, without obtaining the true Damascus figure, as it would be to imitate the pattern by any contortions of iron or steel artificially. These cakes of steel are evidently crystallized, and the future pattern of the sword-blades depends on the size and arrangement of the crystals, modified by so many circumstances, that it is not surprising the proper kind of steel for this purpose should be so rare, or that the secret should have been supposed to be lost. Some of the causes which influence the arrangement, are,—minute portions of the earths, or their metallic bases, entering into chemical combination with the steel; the alloy of other metals contained in the ore; the quantity of carbon absorbed by the iron in its conversion; the weight of metal fused at one time; the quickness or slowness of the cooling, which in all cases affects the laws of crystallization, and in some cases even alters the properties of the crystals themselves; above all, it is highly probable that electrical action may induce a peculiar arrangement of the crystalline structure according to the temperature; but, from whatever cause or combination of circumstances it may arise, it may be rendered self-evident, that the figure or pattern, so long sought after, exists in the cakes of *wootz*, or native steel of India, and only requires to be produced by the action of diluted acids.[2]

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[1] I gave a specimen of Salem steel to an experienced forger, who attempted to work it at various heats without success, and at length declared it to be incorrigibly bad, and perfectly useless for any purpose. I then tried another portion of the same steel myself, and found it could be worked with little more difficulty than ordinary cast-steel; thus proving that, in experiments of this nature, we should never be satisfied with the opinion of one person only, however skilful. These cakes, however, appear to differ very much in quality, and are decidedly inferior to the Cutch steel.

[2] Sulphuric or nitric acid diluted with water may be used for this purpose; but immersion in a bath composed of a solution of sulphate of copper in water, in the proportion of one ounce to a quart, produces a better effect, and exhibits the crystalline arrangement perfectly. The surface of the metal must be previously freed

In the examination of various specimens of *wootz*, I found one large cake of about two and a half pounds' weight, from Cutch, which, on cutting and working, not only furnished excellent steel, capable of being hardened and tempered without much difficulty, but exhibited the Damascus figure, both in the cake itself, and when drawn out by forging into a bar; I also found that this bar could be doubled down on itself four times while red-hot, and then welded perfectly together. Several specimens from Salem, weighing about one pound each, gave only slight indications of a pattern, the crystals being very small, and the steel inferior in quality. Now, it is a singular coincidence, that the trade between Cutch and Damascus was formerly direct; it is therefore highly probable, that the ancient blades were originally made of this steel, and consequently, by mere accidental circumstances, presented a beautiful figure; whereas, if the trade to Damascus had been from any other part of India, where the steel was prepared from a different kind of ore, or in smaller cakes, or in fact, did not contain the pattern within itself, the Syrian workmen might never have become more celebrated for the manufacure of their blades than any other Eastern artisans. I find also that there are two distinct patterns in the Cutch steel I have examined; one can be produced in a few minutes by the action of dilute nitric and sulphuric acids, which show the general arrangement of the crystals in the cake, and their elongation into lines when drawn into a bar; but there is a secondary pattern more complicated, resembling the dark lines in the genuine Damascus, which is much more difficult to bring out, and requires the Oriental methods, or the long-continued action of light and air, to render it perfectly evident; this appears to result from the lines formed by the currents of the fluid mass of metal while cooling, which currents are well known to exist in all fluids when acted upon by increase or decrease of temperature; in the present instance, that portion of the melted steel which is in contact with the sides of the crucible, is cooled faster than the centre, and falls by its superior density, while fresh portions flowing from the centre to the sides, keep up a continuous circulation until the whole mass solidifies; hence arises the radiated appearance on the surface of these cakes of *wootz*, and hence results the more elaborate pattern, or watering, wholly independent of that formed by the elongation of the crystals themselves.

from grease, either by rubbing with wood-ashes and water, as in India, or by smearing it over with a paste of chalk and water, and allowing it to dry on: the time of immersion may vary from ten minutes to half an hour.—H. W.

In all our manufacturing processes, immediate results are demanded, and the effects produced differ considerably from those tained by the more tedious operations of the East, where human time and labour are less esteemed; this may in some measure account for the doubt and difficulty that has attended the investigation of this subject. It is proper, however, to observe, that Dr. Faraday and the late Mr. Stodart made several experiments on *wootz*, and it was not likely that so accurate an observer as Dr. Faraday would fail to discover the pattern in the cakes, and ascribe it to the true cause; but as his experiments were directed rather to ascertain the properties of the steel itself, than to account for the beauty of the finest Oriental blades, the perfect identity between them and the pattern discovered in the Indian steel was still unexplained. I think, however, that, independently of the true germ being discernible in the steel itself, we must remember, that one of these cakes is insufficient to make a sword-blade; every blade must be composed of three at least; a heavy blade would probably require eight, or more, depending on the size, and the skill of the forger, as the cakes seldom exceed two pounds in weight. These cakes, being first drawn into bars, must be welded together, thus forming laminæ by necessity, and not by choice originally; and as the workmen could not fail to discover that, by increasing the number of laminæ, the beauty and the quality of the blade would be improved proportionally, they had only to double the complex bar on itself, and weld again, and thus, by repeating the operation, increase the number of laminæ at pleasure. Now it seems evident, that the reason why the steel in India is made in small lumps instead of larger masses is, that larger and more perfect furnaces would be required in the first instance, and then, for want of powerful machinery, the steel could not be drawn out, or *tilted* into bars; it would not, therefore, be a marketable commodity in countries where manual labour only is employed.

Having forged the blade from such a bar as that before described, the laminæ, or plates, must necessarily be very thin, and in the process of grinding and polishing, break into each other; the indentations of the hammer, and the clumsiness of the forger, even combining to increase the diversity of figure, thus completing all those variegations of pattern so eagerly sought after in every country, and for many centuries.

One illustration, in conclusion, may suffice; if we examine any mass of crystals, such as fluor-spar, for example, one surface of which is polished, we shall perceive all the pattern and indications of its crystalline structure. Let us now suppose such a mass to be drawn out to a considerable length, as in forging, the crystals become spread and elongated into delicate tortuous lines, spreading over and throughout the whole substance, and by the union of several such bars, unequally cut through in various parts, we may, I think, imagine all the variety required to fulfil the condition of my argument, which is to prove, that the figure of the genuine ancient and modern Damascus sword-blades is the result of nature, and not of art.